THE DISABILITY IN SO-CALLED RED-GREEN BLINDNESS AN ACCOUNT BASED ON MANY YEARS OF SELF-OBSERVATION

by

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THIS is an attempt to describe the disability in red-green blindness. It is not an account of the physiology of normal colour vision, nor of the abnormality of the cone cells of the retina in red-green blindness, nor of the genetics of the trait. It does not consider total colour blindness, or colour agnosia, or defects in colour memory. It must be remembered however that the trait is borne as a recessive on the X chromosome. We are dealing with that 6.9 per cent, 1 in 14, of all men who have imperfect, but not absent, perception of red and green (Johnston, Cheeseman and Merrett 1957). For this purpose it is defined as inability to read the figures in the Ishihara test book in good daylight as do normal individuals, and further as misinterpretation of the Ishihara figures in a way standard for the defect or defects. This test seems to identify a group of men each with a similar disability, though the disability cannot be identical because the group seems to include a few pure red blind, a few pure green blind, and a much greater number of men with lesser defects in red and green vision (Rushton, 1975). A more discriminating test would separate these groups and enable one to describe separately the disability in each. It should be noted that without formal testing, very few, or no, red-green blind men come to know they have the defect.

This account does not consider the disability in females. Because red-green blind females are rare, there is little opportunity to study their state. In the only case known to the writer there was no physical defect other than the red-green blindness. One might expect a red-green blind female to be homozygous for the trait, and usually that will be so, but if the Lyon inactivation of one or other X chromosome operates in this disorder, then assuming the inactivation is random, one might expect a range of normality/abnormality in the heterozygote female, varying from normal colour vision to red-green blindness. If a heterozygous female can read both sets of figures on a single Ishihara plate (as seems sometimes to be the case) it may be evidence of mosaicism, and might be consistent with the inactivation of the X chromosome in the cone cells of the retina in an approximately 50/50 proportion.

The disability in red-green blindness (RGB) in ordinary good daylight does not lie in any inability to see red and green colours clearly when the subject is looking at a red or green object which he has already located. There is some difference from normal people in perception of "richness" of colour and there may be in consequence some deficiency of the emotion or feeling-tone associated with the colour. But RGB people can see red and green quite well, and within the reds can

distinguish scarlet, crimson, dull cherry, rose and so on, though pale pink will look off-white, and a very dark green will look black. The disability lies in scanning a background for a red object. The subject may have an equal difficulty with green objects, but that matters less, because one is rarely scanning anywhere for a green object. A RGB person scanning for red objects in a background (as for fuchsia blossom in a hedge, or camellia blossom on a bush, or haws on a hawthorn, or, a better example, wild strawberries on a grassy bank) must scan purposively, slowly, and with attention. If his glance is quick or casual or not purposive, he will miss the red object. In competition with a person of normal colour vision, he cannot win. A normal person will always spot and gather the wild strawberry before him. For another example it is not possible to glance along a street and spot a letterbox instantly, especially if it is a bit dirty with road dust.

In the United Kingdom where traffic lights are always in a standard position on the corner of the footpath at a standard height, there is no difficulty finding the lights, and then no difficulty distinguishing red, orange and green. In New York city, where the lights are affixed to any convenient wall or post in nonstandard positions, the RGB person takes some time to find the lights. Once found they can be interpreted as easily as by a normal person.

In the dusk, unilluminated red objects will look black, and the disability is different, but because one is not usually looking for red objects in the dark, the different disability is rarely noticed and rarely matters. In the dusk or dark a red light has to be intense to be noticeable, and to be identified as red. This is important in all signalling at night. If a military or police picquet on the road at night should attempt to stop cars by showing a red light, one in fourteen male drivers will not see the light easily, or will not see it as red, and drive on. The car may be fired on for failing to stop.

The disability matters in road safety. A red or green car passing from side to side, right to left or left to right, is easily seen and followed because of its movement across the visual field. When such cars, and especially those of certain shades or red and green, are coming directly towards a RGB driver and not moving in the visual field, awareness depends mainly on the colour, and the RGB driver may not see the oncoming car until it is very near him. If the oncoming car were to turn suddenly right at a crossroads, the RGB driver might not see it till too late and drive into it. Or he might on a straight road pull out to pass, and hit the oncoming car, though that is less likely because the oncoming car would move a little in the visual field.

In medicine the medical student will find in the physics class that he can make little of spectroscopy. He will not be able to use the method. In histology eosin stains are hard to see. The RGB student may for long see only the blue-stained nucleus and think that is the whole cell. In haematology the eosinophil granulocyte is hard to find, and in bacteriology the *Mycobacterium tuberculosis* stained by the Ziehl-Neelsen method is faintly seen and not easily located. In the microscopy of urine and faeces red cells do not look very red. In malaria the chromatin dot in the ring form of the parasite and the red Schüffners' dots and Maurer's dots in the red cell are not easily seen. In biochemistry, tests for bilirubin depending on the development of a green colour are hard to assess, and Ehrlich's aldehyde test for

excess urobilin and porphobilinogen in the urine is also difficult. So are the ferric chloride test for aceto-acetic acid and for phenylketonuria, and also the red change in litmus paper in acid solutions. Albustix cannot be used to test for proteinuria. Methods of estimating haemoglobin involving, like the old Sahli method, comparison of haemoglobin solution with red standards are hopeless.

In bedside work assessment of anaemia by skin and conjunctival colour is not so easy as for the normal. The red lines of lymphangitis are not striking and easily overlooked. Red throats do not look so red. The Kayser-Fleichser ring in the cornea is hard to see. It is hard to see the rash of scarlet fever in a fever ward at night. The rose spots of typhoid have to be searched for carefully and also the petechial rash of meningococcal infection. Purpura looks black and not red. A RGB paediatrician is not likely to diagnose pink disease. The cherry red colour of carbon monoxide poisoning is not apparent, and in polycythaemia vera the patient's colour has to be high to be noticed. Microaneurysms in the retina are hard to see. Haemoglobinuria and myoglobinuria look black, and haematuria more black than red. Dark bile in a drainage bag is sometimes very like altered blood. It is not so easy to distinguish fresh melaena (with its black-red colour) from old melaena (totally black). In patients with upper gastrointestinal haemorrhage these are important signs. Venous blood looks more black than red. When giving intravenous iron injections it is hard to tell when the needle is in the vein by withdrawing a little blood in the usual way. Venous blood does not look very different from arterial blood and it would be possible for an unalert RGB person to give an injection into an artery and not a vein, because he might not be warned by the colour of the blood when he withdrew the plunger a little. Red-lined ECG paper is a nuisance. Red lettering on ampoules is hard to read at night, and red graduations on the sphygmomanometer column are faint. Colour codes in red and green on any apparatus especially anaesthetic would be dangerous.

In the ordnance maps of the United Kingdom first and second class roads are not distinguishable. On the London Underground the codes for the Circle (yellow) and Victoria (blue) lines can be seen easily, but the Bakerloo cannot be distinguished from the Central or the Metropolitan, nor the Metropolitan from the Northern, without time, care and a good light.

The RGB golfer on an unfamiliar course will look in vain for the red flag on the next green, and he certainly will not find his red tee in the grass after he drives off. The RGB cricketer will not properly see the crimson colour of the cricket ball and may lose it in its flight. At rifle ranges the red flags are inconspicuous. The big game hunter will not be able to follow easily, or at all, a blood trail in the jungle, and he will not see that red spot through the foliage, occasionally the only indication of a tiger's presence, as is described by Jim Corbett (1947). In early spring the red-green blind will not see the pink flowers on the larch. The bird watcher will not distinguish small birds by colour. He will not see the red colour that gives waxwings and redshanks their name, and he will not see the green of a lapwing's (peeweep's) back. It, like the uniform of the Royal Ulster Constabulary, will look black. The star watcher cannot pick out Mars by its redness. Sunsets and sunrises, while colourful enough, are not the glorious spectacle others describe, and certainly the autumnal and harvest colours, so emotional for some people, leave the RGB unmoved. The rainbow for him is a thing of blue and yellow, and so is chromatic

error in a lens. It is possible, indeed likely, that perception of form and proportion is altered but there seems no way of comparing the perception of the RGB and the normal. One patient of ours with disseminated sclerosis had loss of colour vision in one eye and intact colour vision in the other, but had not the intellectual ability to make use of the remarkable opportunity. Moreover more than perception of red and green was lost in the affected eye.

In the family the RGB husband will never understand why his wife wears the clothes she does, nor can he understand the wife's colour schemes for carpets, curtains and upholstery. Nor will she understand his preference for blues and yellows. The RGB husband should think before buying his wife sapphires or amethysts. She may prefer the rubies or emeralds which seem less brilliant and attractive to him. Parents should know early about their sons' RGB. Otherwise they may be angry and unkind when the boys fail to see things. A boy sent to find a brown or red article in an ill-lit room may not be able to find it, though it is plain and even prominent to a parent of normal vision. He may gain a life-long reputation for either lying or uselessness.

How far RGB is a handicap for a soldier is hard to say but it is certain to be considerable. Colour codes, colour signals by flag, lamp or rocket, red and green markings on maps or on dangerous objects, red reference points on the ground, all make errors possible. Certainly, all recruits of all ranks should be tested and their colour vision recorded. In industry, especially in engineering of all kinds, engineers and managers should remember that red warning signs and marks may not be seen.

SUMMARY

An account has been given of the disability in red-green blindness based on many years of self observation and of testing applicants for employment. The main disability is inefficiency in scanning a background for red objects. Once located the red object can be seen satisfactorily enough. Red-green blind persons should be identified early in life and then the particulars of their disability taught to them item by item both in respect of general experience and of their occupations.

The RGB person is excluded by regulation from being a deck officer at sea, an aircraft pilot, a railway engine driver, or signalman, but the RGB person can have a successful career in almost any other occupation. The difficulties are overcome by awareness, self-training and effort. Nevertheless RGB doctors would be better to avoid careers in haematology, histology and bacteriology. RGB young men should consider well before training as electricians, dyers, paint merchants, painters, drapers, clothiers, upholsterers and curtain supplying. All children should have colour vision tests as soon as possible after entering school and the implication of red-green blindness should be explained to the parents. For road safety, motorcars should not be monocoloured red or green. Blue and yellow would be safer warning colours than red and green.

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